EFFECT OF POSTHARVEST HOT-WATER TREATMENTS ON SPOILAGE OF CRANBERRIES IN STORAGE

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EFFECT OF POSTHARVEST HOT-WATER TREATMENTS ON SPOILAGE OF CRANBERRIES IN STORAGE

By R. E. ANDERSON, *Research Horticulturist*, and WILSON L. SMITH, JR., *Research Plant Pathologist, Market Quality Research Division, Agricultural Research Service* [1]

SUMMARY

Hot-water treatments to reduce the development of spoilage of cranberries during or after storage were tested for 3 years. Treating berries before storage in 110°, 115°, 120°, or 125° F. water for 20, 10, 5, and 2½ minutes, respectively, reduced the number of pathogens that survived, but did not always reduce the total spoilage of the berries. Generally the hot-water treatments reduced the development of spoilage better in early-harvested than in late-harvested berries. Hot-water treatments apparently increased the amount of physiological breakdown in late-harvested berries. The early-harvested berries developed less spoilage than the late-harvested ones.

INTRODUCTION

Losses of cranberries in storage are due largely to physiological breakdown and decay. Storage at 32° F. delays the development of decay, but losses due to low-temperature breakdown increase. This type of breakdown can be reduced by storage at 36° to 40° *(11)* [2] or by intermittent warming *(6)*. However, at 36° to 40° development of decay is not delayed as much as it would be at 32°. Much of the decay that develops in storage results from infection that occurred in the field during and immediately after flowering, when the fungi causing fruit rots enter the flowers and developing fruit *(3)*. Field applications of fungicides have reduced the amount of decay but have not eliminated it, either in the field or in storage *(2, 4, 8, 9, 12)*. Recently hot-water treatments have proved effective in preventing development of decay in fruits and vegetables already infected *(1, 5, 7, 10)*. Hot-water treatments, therefore, were tested to reduce development of decay in cranberries during storage.

In preliminary tests berries were severely damaged by dipping them in water at 140° F. for 1 minute, at 131° for 2 minutes, or at 125° for 5 minutes. Dipping in water at 131° for 1 minute, 125° for 2½ minutes, 120° for 7 minutes, 115° for 10 minutes, or 110° for 20 minutes did not damage the fruit. Isolations from decayed berries showed that the hot-water treatments reduced the number of viable pathogens.

TEST I

Materials and Methods

Late Howes cranberries were obtained from the University of Massachusetts Cranberry Station at East Wareham, Mass. shortly after harvest in mid-October for a storage test at Beltsville, Md. The berries were handsorted to remove all that were visibly spoiled or damaged. The cleaned berries were then inoculated by dipping them in a slurry of ground decayed berries and water for 1 minute. After removal from this slurry, the berries were allowed to dry.

Sample size was 100 berries per treatment. Treatments included a dry control and the following water-immersion dips: 20 and 10 minutes at 70° F.; 20, 10, 5, and 2½ minutes at 110°; 10, 5, and 2½ minutes at 115°; 5 and 2½ minutes at 120°; and 2½ and 1¼ minutes at 125°. After treatment, the berries were air-dried and placed in new 3-lb. kraft paper bags, which were sealed and placed in storage. Five duplicate samples of each treatment were stored at 38°, and four duplicate samples were stored at 70°. Those stored at 70°

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[2] Italicized numbers in parentheses refer to Literature Cited, p. 8.

were inspected after 1, 2, 4, and 6 weeks, and those at 38° after 2, 3, 4, 5, and 6 months. Duplicate samples of 100 berries were examined at each inspection. After the removal inspection of the 38° stored samples, the remaining good berries were held 7 days at 70° and reinspected. Spoilage after the 7 days was included with the spoilage that was present at removal.

Spoilage, as classified in these tests (except where noted), included berries that were considered to be unmarketable due either to decay or to physiological breakdown.

After each removal inspection of the 38° F. lots, 10 spoiled berries were selected from representative treatments. Isolations were made from each spoiled berry on potato dextrose agar. These isolates were incubated at 75° and observed to determine the percent survival of cranberry pathogens.

Results

70° storage

Spoilage of cranberries at 70° F. usually increased with the length of storage (table 1). Those dipped in 110° water for 20 minutes and in 120° for 5 or 2½ minutes and in 125° water for 2½ minutes developed significantly less spoilage than the wet controls, which had b dipped in 70° water. All of the berries gi the hot-water dips developed less spoilage tl the dry controls.

TABLE 1.—*Spoilage of cranberries in storage at 70° F.*

Prestorage treatment		Spoilage after[1] —				
Water temp.	Dip time	1 week	2 weeks	4 weeks	6 weeks	Mean[2]
°F.	*Min.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
70	20	12	17	16	31	19 cde
70	10	22	21	17	20	20 de
110	20	6	7	11	21	11ab
110	10	10	14	10	15	12 bc
110	5	8	11	14	20	13 bcd
110	2½	3	9	13	22	12 bc
115	10	10	12	11	15	12 bc
115	5	10	9	19	14	13 bc
115	2½	10	9	17	27	16 bcd
120	5	10	7	7	15	10ab
120	2½	7	5	7	14	8ab
125	2½	3	2	6	7	5a
125	1¼	8	11	13	17	12 bc
Dry control		17	22	22	31	23 e
Mean		9.7	11.1	13.1	19.2	13.3

[1] Individual values represent mean of duplicate samples of 100 berries each.

[2] Means are of 8 samples. Duncan Multiple Range Test letters are for significance at 1-percent level. Means followed by letter in common do not differ significantly from one another.

38° storage

Cranberries given the longest exposure each of the hot-water treatments had sigı cantly less spoilage than the wet control (tε 2). Also all of the hot-water treated berı except the 2½-minute dips in 110° or 115° water had significantly less spoilage than dry control. Within each hot-water treatm decreasing the dipping time resulted ir greater amount of spoiled berries. Despite treatment, spoilage increased with time storage.

Pathogen survival

Growth of fungi isolated from nonheε spoiled berries resembled that of the previ ly described cranberry pathogens *Godro Sporonema,* or *Pestalotia (8).* The surviva these pathogens after storage was least in same hot-water treated lots in which spoi was least. Within each of the higher temp ture dips, the shorter dipping time was ineı tive in reducing pathogen survival (table 3

TEST II

Materials and Methods

Another test was set up the following sea using cranberries harvested in October f three different bogs in Massachusetts.] sorted and nonsorted berries were used. sorting consisted of running the beı through a commercial cranberry separator, lowed by passage over a ½-inch-wire-r screen. The nonsorted berries were use brought in from the field, in the chaff. Spoi for the sorted berries at this time ranged 1 4.2 to 4.6 percent, and for the nonsorted beı from 4.4 to 12.5 percent.

Three prestorage treatments were tes (1) dry control, (2) 115° F. water dip fo minutes, and (3) 125° water dip for 2½ utes. After the dip treatments, the berries pound samples) were air-dried at room ten ature and packaged in 1-pound waxed caı with a transparent film window. Three ı cate cartons of each treatment from each were placed in each of three storage hous

After storage for 4 months at about 38 100 berries from each sample were insp and the remainder of the sample placed at After 7 days at 70°, a second 100-berry sa was inspected for spoilage.

TABLE 2.—*Spoilage of cranberries after storage at 38° F. plus 7 days at 70°*

Prestorage treatment		Spoilage after [1] —					
Water temp.	Dip time	2 months	3 months	4 months	5 months	6 months	Mean [2]
°F.	*Min.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
70	20	20	30	36	54	63	41 defg
70	10	29	32	44	55	67	45 fg
110	20	18	14	24	28	39	25ab
110	10	18	23	42	55	58	39 def
110	5	20	22	33	46	58	36 cdef
110	2½	23	37	41	48	65	43 efg
115	10	12	11	24	26	39	23a
115	5	21	19	30	36	58	33 bcd
115	2½	21	31	39	50	63	41 defg
120	5	12	24	22	31	50	28abc
120	2½	12	27	36	40	56	34 bcde
125	2½	16	21	20	22	39	23a
125	1¼	11	20	33	53	47	33 bcd
Dry control		32	45	47	58	64	49 g
Mean		19	25	34	43	55	35

[1] Individual values represent mean of duplicate samples of 100 berries each.
[2] Means are of 10 samples. Duncan Multiple Range Test letters are for significance at 1-percent level. Means followed by letter in common do not differ significantly from one another.

TABLE 3.—*Survival of pathogens in cranberries stored at 38° F.*

Prestorage treatment		Pathogens recovered after storage [1]					
Water temp.	Dip time	2 months	3 months	4 months	5 months	6 months	Mean [2]
°F.	*Min.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*	*Pct.*
70	20	100	90	70	100	90	90 d
110	20	40	30	40	20	50	36a
110	10	60	80	80	90	90	80 cd
115	10	20	20	60	40	30	34a
115	5	80	90	80	90	90	86 d
120	5	50	80	30	40	60	52abc
120	2½	60	60	100	80	80	76 cd
125	2½	30	20	20	70	90	46ab
125	1¼	50	60	80	80	90	72 bcd
Dry control		100	90	90	100	90	94 d

[1] Individual values obtained from isolations made from 10 berries per duplicate sample after indicated storage period.
[2] Duncan Multiple Range Test at 1-percent level. Means followed by letter in common are not significantly different from one another.

Results

On removal from storage, both the sorted and nonsorted berries from bog I that were treated with 115° or 125° F. water had significantly less spoilage than the controls (table 4). The hot-water treatments did not reduce the development of spoilage in berries from the other two bogs. In fact, the hot-water treatments increased spoilage of the nonsorted berries from bog III.

After 7 days at 70° F., sorted berries from bog I treated with 115° or 125° water had less spoilage than the controls (table 5). The heated nonsorted berries had about the same amount of spoilage as the controls. The hot-water treat-

TABLE 4.—*Spoilage of cranberries from different bogs after 4 months' storage at 38° F.*

Prestorage treatment	Spoilage[1]				
	Bog I	Bog II	Bog III	Treatment mean	Mean
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Sorted berries					23a
Control	19 cd	22 b	31ab	24 b	
115° F. water (10 min.)	13ab	25 b	36 bc	25 b	
125° F. water (2½ min.)	12a	23 b	20a	19a	
Nonsorted berries					26 b
Control	22 d	20ab	30ab	24 b	
115° F. water (10 min.)	16abc	20ab	50 d	29 b	
125° F. water (2½ min.)	17 bc	16a	44 cd	26 b	
Bog mean	16a	21 b	35 c		

[1] Each value is the mean of nine 100-berry samples. Compare means within blocks only. Means followed by no letters in common differ from each other at the 5-percent level as determined by the Duncan Multiple Range Test.

ments did not reduce the amount of spoilage that developed in berries from bogs II or III and even increased it in several lots of berries.

The overall means show sorted berries treated in 125° F. water for 2½ minutes had less spoilage when they were removed from storage than those from the other hot-water treatments or the control (table 4—treatment means). This treatment, however, did not reduce spoilage of the nonsorted berries. Seven days after removal from storage, neither of the hot-water treatments effectively reduced spoilage (table 5–treatment means).

Differences in spoilage between sorted and nonsorted berries were small. At removal from storage, sorted berries had significantly less spoilage than did the nonsorted berries (table 4). After 7 days' holding at 70° F. the sorted and nonsorted berries had about the same amount of spoilage (table 5).

Cranberries from the different bogs developed different amounts of spoilage (tables 4 and 5—bog means). Both at removal from storage and after the 7-day holding period, berries from bog I had the least, and those from bog III the greatest, amount of spoilage.

There may be a possible explanation for these different responses of berries from the different bogs. Cranberries from bog I were harvested 2 weeks earlier than those from bog II, which in turn were harvested 3 days earlier than those from bog III. This might indicate that less decay is likely to occur in early-harvested or less mature berries. It might also indicate that the earlier harvested berries are more tolerant to heat treatments than are later harvested ones. The latter may be more susceptible to injury by hot water.

TEST III

Materials and Methods

The theory that maturity of cranberries may influence the amount of decay and susceptibility to heat damage was investigated the following season. Three harvests of Late Howes cranberries were made from each of three bogs in Massachusetts at approximately 10-day intervals. The first harvest was about 10 days earlier than the commercial harvest date of this variety. At each harvest, berries were sorted on a commercial separator and passed over a ½-inch mesh wire screen to remove chaff, very small berries, and most of the spoiled berries.

All lots were treated at Beltsville, Md. within

TABLE 5.—*Spoilage of cranberries from different bogs after storage at 38° F. for 4 months plus 7 days at 70°*

Prestorage treatment	Spoilage[1]				
	Bog I	Bog II	Bog III	Treatment mean	Mean
	Pct.	*Pct.*	*Pct.*	*Pct.*	*Pct.*
Sorted berries					33a
Control	27 c	29ab	39a	32a	
115° F. water (10 min.)	19a	39 c	48 b	35a	
125° F. water (2½ min.)	20ab	36 bc	39a	32a	
Nonsorted berries					34a
Control	26abc	27a	36a	30a	
115° F. water (10 min.)	23abc	31ab	58 c	37a	
125° F. water (2½ min.)	26abc	28a	52 b	35a	
Bog mean	24a	32 b	45 c		

[1] Each value is the mean of nine 100-berry samples. Compare means within blocks only. Means followed by no letters in common differ from each other at the 5-percent level as determined by the Duncan Multiple Range Test.

2 weeks of harvest. Initial inspection after harvest showed that spoilage ranged from 0.3 to 4.5 percent in fruit from the three bogs. The greatest spoilage was in the berries harvested last. Treatments before storage were as follows: (1) dry control, (2) 115° F. water dip for 10 minutes, and (3) 125° water dip for 2½ minutes. Three 1-pound samples of each treatment for each harvest and from each bog were stored at 38° for 3 months. On removal from storage, one 100-berry sample from each 1-pound carton was examined for spoilage. The remaining berries were placed at 70°, and three 100-berry samples from each carton were examined for spoilage after 1 week.

Results

On removal from 3 months of storage, the early- and midseason-harvested cranberries treated with 115° or 125° F. water had considerably less spoilage than the controls (table 6). Berries from the late harvest given the 115° water-dip treatment also had less spoilage than the controls, but those given the 125° treatment had almost triple the amount of spoilage in the control.

After 7 days at 70° F. treated berries from the early harvest had significantly less spoilage than the controls (table 7). There was no significant difference in the amount of spoilage between the control and either of the heat-treated lots from the midseason harvest. Berries receiving the 125° water treatment of the late harvest had significantly more spoilage than either the control or the 115° water-treated fruit. Treatment means showed that berries receiving the 115° water treatment developed less spoilage than did those from the 125° treatment or the control.

In this test an attempt was also made to separate spoilage due to pathological decay or to physiological breakdown. By comparing data in tables 7 and 8, the amount of spoilage due to physiological breakdown becomes apparent. Most of the spoilage of the berries, except those from the late harvest given the 125° F. water-dip treatment, appeared to be caused by decay-producing organisms. In the late harvest more than half the spoilage of the berries treated in 125° water was due to nonpathological breakdown. These berries apparently were severely injured by the hot-water treatment, which caused an increase in physiological breakdown.

In general, the later the cranberries were

TABLE 6.—*Spoilage of cranberries of different harvest periods after 3 months' storage at 38° F.*

Prestorage treatment	Spoilage [1] Harvest period: Early	Midseason	Late	Treatment mean
	Pct.	*Pct.*	*Pct.*	*Pct.*
Control	17 b	17 b	22 c	19 b
115° F. water (10 min.)	6a	8a	11a	8a
125° F. water (2½ min.)	8a	9a	60 d	26 c
Harvest mean	10a	11a	31 b	

[1] Each value is the mean of three 100-berry samples, each from a different bog. Compare means within blocks. Means followed by no letters in common differ from each other at the 5-percent level as determined by the Duncan Multiple Range Test.

TABLE 7.—*Spoilage of cranberries of different harvest periods after 3 months' storage at 38° F. plus 7 days at 70°*

Prestorage treatment	Spoilage [1] Harvest period: Early	Midseason	Late	Treatment mean
	Pct.	*Pct.*	*Pct.*	*Pct.*
Control	21 bc	22 bc	29 d	24 b
115° F. water (10 min.)	9a	16ab	23 cd	16a
125° F. water (2½ min.)	11a	19 bc	84 e	38 c
Harvest mean	14a	19 b	46 c	

[1] Each value is the mean of nine 100-berry samples. Compare means within blocks. Means followed by no letters in common differ from each other at the 1-percent level as determined by the Duncan Multiple Range Test.

harvested, the greater the amount of spoilage, regardless of the treatment or the bog from which the berries were obtained. Some difference in spoilage also occurred in the berries from the different bogs (table 9). The bog with most spoilage the previous season (data not shown) had the least spoilage in Test III (table 9).

DISCUSSION AND CONCLUSIONS

On the basis of these tests, the use of brief hot-water treatments before storage of cranberries is not recommended as a method of controlling spoilage. Data show that a large percentage of the organisms causing cranberry decay can be killed by treatment in 110° to

TABLE 8.—*Decay of cranberries of different harvest periods after 3 months' storage at 38° F. plus 7 days at 70°*

Prestorage treatment	Decay [1]			
	Harvest period			Treatment mean
	Early	Midseason	Late	
	Pct.	*Pct.*	*Pct.*	*Pct.*
Control	20 cd	19 bcd	22 d	20 b
115° F. water (10 min.)	7a	13ab	19 bcd	13a
125° F. water (2½ min.)	8a	13ab	37 e	19 b
Harvest mean	11a	15 b	26 c	

[1] Each value is the mean of nine 100-berry samples. Compare means within blocks. Means followed by no letters in common differ from each other at the 5-percent level as determined by the Duncan Multiple Range Test.

TABLE 9.—*Spoilage of cranberries of different harvest periods from different bogs after 3 months' storage at 38° F. plus 7 days at 70°*

Bog	Spoilage [1]			
	Harvest period			Bog mean
	Early	Midseason	Late	
	Pct.	*Pct.*	*Pct.*	*Pct.*
I	16ab	20ab	50 d	28 b
II	16ab	25 bc	52 d	31 c
III	8a	11ab	35 c	18a
Harvest mean	14a	19 b	46 c	

[1] Each value is the mean of nine 100-berry samples. Compare means within blocks. Means followed by no letters in common differ from each other at the 1-percent level as determined by the Duncan Multiple Range Test.

125° F. water, but total spoilage of the berries during storage and a simulated marketing period was not greatly reduced. It would appear, therefore, that more knowledge of the causes of physiological breakdown of cranberries must be obtained before hot-water treatments can be successfully applied. The present study indicates that the harvest date of the fruit is a major factor contributing to spoilage of cranberries during subsequent storage. With early-harvested berries, treatment in either 115° or 125° water gave satisfactory control of spoilage. For the midseason or late-harvested berries, treatment in 115° water is preferable, as apparently less physiological breakdown occurred on berries treated at this temperature than on those treated at 125°.

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